BIOFIDELITY ASSESSMENT OF NUMERICAL HUMAN AND DUMMY MODELS IN CRASH TEST CONDITIONS

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Increasingly stringent international passenger safety norms and the need to reduce vehicle body weight for environmental and protection requirements demand efficient and innovative design methods. Computer simulation, or virtual testing, allows an integrated evaluation of these aspects in the early design stages and thereby reduces costs for prototyping and time-to-market. Virtual testing is already widely applied in vehicle passive safety design. A number of numerical methods are commonly used to model the physical events in a car crash at various levels of detail (e.g., finite element and multibody). However, these numerical methods do not produce similar results in all cases. In addition, a range of models with varying quality exists for all components involved in a car crash, including models of the occupant, restraint system, vehicle, and impactor.

Of these components, the models of the regulated crash dummies are the most extensively validated. However, a user might not always be aware of the level of validation of these dummy models and can, therefore, inadvertently use the model beyond its validated range. In addition, the biofidelity of physical dummies, and consequently their numerical counterparts, is questionable. Detailed models of the real human body could provide more biofidelic response and potentially allow the simulation of injury mechanisms at tissue level. A range of human models have recently been developed, but with varying (and sometimes questionable) levels of validation.

To make matters even more complicated, objective criteria to rate the correlation between numerical and experimental data are lacking, resulting in highly subjective ‘validation’ of models. Consequently, models that describe the same physical situation, but which have been developed and validated at different sites and/or with different tools cannot be compared directly. This situation greatly hinders the acceptance of virtual testing as part of occupant safety regulations and calls for the definition of general procedures to create validated models and objective criteria to rate the numerical results. The availability of such procedures and guidelines is an essential step towards the application of virtual testing in regulated crash safety assessments.

In this paper, general validation procedures for occupant (dummy and human) models are presented. The use of these validation procedures are exemplified by state-of-the-art dummy and human models developed at TNO. The validated models are then applied in simulations of standardised crash tests (such as FMVSS and NCAP). The responses obtained with the dummy and human models are compared. Based on the simulation results, the biofidelity and injury predictive capabilities of the dummy and human models are assessed.